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METHODS AND SYSTEMS FOR DETECTING AND PREVENTING
SIGNALING CONNECTION CONTROL PART (SCCP) LOOPING

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Description

METHODS AND SYSTEMS FOR DETECTING AND PREVENTING SIGNALING CONNECTION CONTROL PART (SCCP) LOOPING

5

Technical Field

The present invention includes methods and systems for detecting and preventing SCCP looping. More particularly, the present invention includes methods and systems for detecting and preventing SCCP looping even when the originating point code (OPC) and the post-global-title-translation (GTT)
10 destination point code (DPC) are not the same.

Related Art

In packet-switched networks, circular routing or looping refers to the same message being sent back and forth repeatedly between a source and a
15 destination. Such a phenomenon can occur due to misconfiguration of network routing tables or in routing address translation tables. Looping is undesirable because it increases network congestion and consumes processing resources in the nodes involved in circularly routed messages.

In SS7 networks, looping can occur at the message transfer part (MTP)
20 level and at the signaling connection control part (SCCP) level. At the MTP level, looping may occur due to misconfiguration in MTP routing tables. For

example, an MTP routing table may route a message with a particular destination point code to the originating point code of the node that sent the message. Such misconfiguration may occur when network nodes are managed by different service providers.

5 At the MTP level, the SS7 protocol specifications allow for loop detection by two methods, referred to as congestion detection and rerouting. In both methods, SS7 industry standard specifications specify that a route set test message with a priority of three may be sent from a source node to a destination node. If the route set test message is sent back to the source
10 node, a circular route is detected and the link is failed.

 Loop detection at the SCCP level is more complex than loop detection at the MTP level because of global title translation. Global title translation is the process by which the called party address stored in the SCCP portion of a message is translated into a destination point code, and the original destination
15 point code in the MTP routing label of the message is replaced by the translated destination point code. Global title translation is frequently used when a sending node does not know the final destination point code for a signaling message. The sending node relies on one or more intermediate nodes to perform global title translation for the signaling message to determine
20 the proper destination point code for the signaling message. Even if the MTP routing tables at all nodes between an SCCP source and SCCP destination are correct, looping can occur due to misconfiguration in an intermediate node's global title translation tables. Such misconfiguration may occur when nodes are owned by different network operators.

With the advent of local number portability where a called party can move to a different location and keep the same directory number, SCCP looping has become even more prevalent because STPs often use additional point codes, referred to as capability point codes to identify themselves for LNP
5 purposes. Capability point codes make SCCP looping difficult to detect because the destination address of a global-title-translated message may not match the originating address in the original message, but the addresses may still correspond to the same node.

Like MTP looping, SCCP looping causes congestion between nodes and
10 is therefore undesirable. The SS7 protocol specifications currently specify two methods for SCCP loop detection. However, both of these methods require network-wide implementation. One method is the SCCP hop counter provided by extended unit data service. In order to implement the SCCP hop counter, each node involved in loop detection is required to increment and check an
15 SCCP hop count in an SCCP extended unit data message to determine whether the hop count exceeds a predetermined value. If the hop count exceeds a predetermined value, SCCP looping is indicated and the message is discarded. However, many network nodes do not participate in extended unit data service. As a result, using SCCP extended unit data service is unsuitable
20 for detecting SCCP looping absent network-wide implementation of extended unit data service.

The other method described in SS7 protocol specifications for SCCP loop detection is the operations, maintenance, and administration part (OMAP) SRVT protocol. The OMAP SRVT protocol, like the extended unit data

protocol, requires network-wide compliance. The problem of SCCP looping is also prevalent in IETF Sigtran protocols used to carry SCCP traffic, because such protocols carry SCCP traffic as a payload, with the exception of the SCCP user adaptation layer.

5 One conventional method for detecting SCCP looping in a network that does not participate in the XUDT or OMAP protocols is to use a link monitor to the signaling links between two nodes and detect the presence of looping based on link utilization. If link utilization detected by the link monitor exceeds a predetermined threshold, circular routing or looping is detected, the link is
10 taken out of service, and the routing tables are reconfigured. Using link utilization as a signature for SCCP loop detection can be inaccurate because link utilization may increase due to legitimate non-looping traffic. Moreover, taking a link out of service is labor intensive and increases traffic on other links.

 Another conventional method for detecting SCCP looping is to compare
15 the post-GTT DPC to the inbound MTP OPC in a signaling message. While this method for SCCP loop detection will prevent some instances of SCCP looping, it is ineffective when the source and destination of an SCCP loop are not adjacent to each other. Moreover, in SS7 networks, many nodes use capability point codes and true point codes to identify each other. As a result,
20 the OPC in the pre-GTT message and the post-GTT DPC in the outbound message may not be the same. However, the OPC and the DPC, even though they are different from each other, may indicate the same node in networks where signaling nodes use multiple point codes to identify themselves. Thus,

there exists a long felt need for improved methods and systems for detecting and preventing SCCP looping.

Disclosure of the Invention

5 The present invention includes methods and systems for detecting and preventing SCCP looping that do not require network wide implementation of complex loop detection protocols. SCCP looping according to the present invention can be implemented at a single network node or pair of nodes using loop detection logic and appropriate loop detection data identifying nodes for
10 which SCCP loop protection is desired. In addition, the methods and systems of the present invention are capable of detecting SCCP looping when the source and destination of the SCCP loop are not adjacent to each other.

 A method for detecting SCCP looping may include receiving an SCCP message and performing global title translation on the SCCP message. As a
15 preliminary check, the post-GTT DPC in the message may be compared to the OPC in the message. If the OPC matches the DPC, then SCCP looping is indicated. If the OPC does not match the post-GTT DPC, the post-GTT DPC may be compared to one or more additional point codes to detect the presence of SCCP looping. The additional point codes may include capability point
20 codes, true point codes, and/or secondary true point codes of nodes for which SCCP loop protection is desired. If the post-GTT DPC matches any of these additional point codes, SCCP looping may be indicated. Because such loop detection does not depend on network-wide implementation of SCCP looping procedures, the methods and systems of the present invention provide robust

protection than the SCCP looping mechanism in the SS7 protocol specifications. In addition, because the present invention compares the post-GTT DPC value to point codes other than the OPC in a received signaling message, SCCP loop detection can be successful even if the post-GTT DPC
5 and the OPC are different.

Accordingly, it is an object of the invention to provide improved methods and systems for SCCP looping that do not require network-wide implementation of loop detection procedures.

It is another object of the invention to provide methods and systems for
10 SCCP loop detection in which point codes other than the OPC in a received signaling message are compared to the post-GTT DPC.

Some of the objects of the invention having been stated hereinabove, and which are addressed in whole or in part by the present invention, other objects will become evident as the description proceeds when taken in
15 connection with the accompanying drawings as best described hereinbelow.

Brief Description of the Drawings

Preferred embodiments of the invention will now be explained with reference to the accompanying drawings of which:

20 Figure 1 is a network diagram illustrating conventional SCCP looping;
Figure 2 is a block diagram illustrating exemplary internal architecture of a signal transfer point including an SCCP loop detector according to an embodiment of the present invention;

Figure 3 is a flow chart illustrating exemplary steps that may be performed by an SCCP loop detector according to an embodiment of the present invention;

Figure 4 is a network diagram illustrating an exemplary operating
5 environment for an SCCP loop detector according to an embodiment of the present invention;

Figure 5 is a network diagram corresponding to the network in Figure 4 illustrating a message flow for an inbound message from an adjacent STP destined for an adjacent STP in the concurring direction according to an
10 embodiment of the present invention;

Figure 6 is a network diagram corresponding to the network in Figure 4 illustrating a message flow for an inbound message from an adjacent STP to an adjacent STP in the opposing direction according to an embodiment of the present invention;

15 Figure 7 is a network diagram corresponding to the network in Figure 4 illustrating an exemplary message flow for an inbound message from an adjacent STP destined for a non-adjacent STP in the concurring direction according to an embodiment of the present invention;

Figure 8 is a network diagram corresponding to the network in Figure 4
20 illustrating an exemplary message flow for an inbound message from an adjacent STP destined for a non-adjacent STP in the opposing direction according to an embodiment of the present invention;

Figure 9 is a network diagram corresponding to the network in Figure 4 illustrating an exemplary message flow for an inbound message from an

adjacent STP destined for a non-adjacent STP in the concurring direction according to an embodiment of the present invention;

Figure 10 is a network diagram corresponding to the network in Figure 4 illustrating an exemplary message flow for an inbound message from a non-adjacent STP destined for an adjacent STP in the opposing direction according to an embodiment of the present invention;

Figure 11 is a network diagram corresponding to the network illustrated in Figure 4 of an exemplary message flow for a message from a non-adjacent STP destined for a non-adjacent STP in the concurring direction according to an embodiment of the present invention;

Figure 12 is a network diagram corresponding to the network in Figure 4 illustrating an exemplary message flow for a message from a non-adjacent STP destined for a non-adjacent STP in the opposing direction according to an embodiment of the present invention;

Figure 13 is a network diagram illustrating an exemplary operating environment for an SCCP loop detector where nodes do not use capability point codes according to an embodiment of the present invention;

Figure 14 is a flow chart illustrating exemplary steps that may be performed by an SCCP loop detector in a network in which capability point codes are not used according to an embodiment of the present invention;

Figure 15 is a network diagram corresponding to the network in Figure 13 illustrating an exemplary message flow for an inbound message from an adjacent STP to an adjacent STP in the concurring direction according to an embodiment of the present invention;

Figure 16 is a network diagram corresponding to the network in Figure 13 illustrating an exemplary message flow for a message from an adjacent STP to an adjacent STP in the opposing direction according to an embodiment of the present invention;

5 Figure 17 is a network diagram corresponding to the network in Figure 13 illustrating an exemplary message flow for a message from an adjacent STP to a non-adjacent STP in the concurring direction according to an embodiment of the present invention;

 Figure 18 is a network diagram corresponding to the network in Figure
10 13 illustrating an exemplary message flow for an inbound message from an adjacent STP to a non-adjacent STP in the opposing direction according to an embodiment of the present invention;

 Figure 19 is a network diagram corresponding to the network in Figure
13 illustrating an exemplary message flow for a message from an adjacent STP
15 to a non-adjacent STP in the concurring direction according to an embodiment of the present invention;

 Figure 20 is a network diagram corresponding to the network in Figure
13 illustrating an exemplary message flow for an inbound message from a non-adjacent STP to an adjacent STP in the opposing direction according to an
20 embodiment of the present invention;

 Figure 21 is a network diagram corresponding to the network in Figure 13 illustrating an exemplary message flow for a message from a non-adjacent STP to a non-adjacent STP in the concurring direction according to an embodiment of the present invention; and

Figure 22 is a network diagram corresponding to the network in Figure 13 illustrating an exemplary message flow for an inbound message from a non-adjacent STP to a non-adjacent STP in the opposing direction according to an embodiment of the present invention.

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Detailed Description of the Invention

Figure 1 is a network diagram illustrating conventional SCCP looping. Referring to Figure 1, a plurality of STPs **100, 102, 104, 106, 108, and 110** are interconnected between an SSP **112** and an SSP **114**. In the illustrated example, each STP includes a true point code (TPC), a secondary true point code (SCP), and a capability point code (CPC). True point codes and secondary true point codes are point codes that each STP uses to identify itself in the OPC fields of messages that it originates. A capability point code is a point code used by other nodes to send messages to a pair of STPs. The particular STP that processes a message addressed to its capability point code may depend on load sharing considerations.

In the illustrated example, SSP **112** originates a message, MSU 1, and sends the message to STP B **102**. MSU 1 is assumed to have the following fields:

20 MTP OPC = 244-2-1
 MTP DPC = 2-2-2
 SCCP RI = route-on-gt

The message is assumed to be sent route on global title. When STP B **102** receives the message, STP B **102** performs an intermediate global title translation on the MSU, resulting in MSU 1A. MSU 1A, after translation, will have the following fields:

5 MTP OPC = 3-3-3
 MTP DPC = 5-5-5
 CGPA OPC = 244-2-1
 CDPA DPC = 5-5-5.

When MSU 1A arrives at STP D **106**, STP D **106** is assumed to have an
10 erroneously configured global title translation table or LNP Message relay data.

This may occur because STP D **106** is owned by a different network operator than STP B **102**. In this example, STP D **106** is assumed to perform a looping translation. The result of the translation is MSU 1B. MSU 1B is assumed to have the following fields:

15 MTP OPC = 6-6-6
 MTP DPC = 2-2-2
 CGPA OPC = 244-2-1
 CDPA DPC = 6-6-6.

STP D **106** sends the erroneously translated message to STP B **102**. STP B
20 **102** performs global title translation on MSU 1B, resulting in the same fields as listed above for MSU 1A. As a result, MSUs 1A and 1B continuously loop between STP B **102** and STP D **106**. It should also be noted that the post-GTT DPC in MSU 1B does not match the OPC of MSU 1A because the MSU 1B is

sent to a DPC corresponding to the capability point code of STP B **102**. As a result, conventional SCCP loop detection logic that compares the post-GTT DPC with the OPC of a received message is ineffective for stopping the SCCP looping illustrated in Figure 1.

5 According to one exemplary implementation of the invention, a signal transfer point may solve the SCCP looping issue illustrated in Figure 1 without requiring SCCP protocol changes or network-wide implementation of such changes. In the simple example illustrated in Figure 1, one solution to prevent SCCP looping is not using capability point codes and instituting a check to
10 determine whether the incoming MSU's OPC is the same as the post-GTT DPC. However, many domestic operators use capability codes not only for SCCP, but also for LNP. Thus, in such networks, one possible solution to preventing SCCP looping is to correlate capability point codes associated with SCCP or database application, such as LNP, with true/secondary point codes.

15 For example, in the example illustrated in Figure 1, prior to transmitting MSU 1B and placing its MTP point code in the MSU, STP D **106** may examine the OPC of MSU 1A (3-3-3) and the post-GTT DPC of MSU 1B (2-2-2). Since there is no match, STP D **106**, according to one exemplary implementation, may also check a table that maps or correlates the OPC of the original
20 message to one or more additional point codes and compares the post-GTT DPC to the additional point codes. For example, STP D **106** may correlate the OPC of MSU 1A to 2-2-2, the CPC of STP B **102**. Since 2-2-2 matches the post-GTT DPC, STP D **106** may determine that looping is present.

Figure 2 is a block diagram of an STP including SCCP loop detection functionality according to an embodiment of the present invention. Referring to Figure 2, STP **200** includes a plurality of internal processor cards **202**, **204**, **206**, and **208** connected to each other via a pair of counter-rotating ring buses

5 **210**. In the illustrated example, the internal processor cards include a link interface module **202** for sending and receiving messages over SS7 signaling links, a data communications module **204** for sending and receiving SS7 and other types of signaling messages over IP signaling links, and database services modules **206** and **208** for performing global title translation and SCCP

10 loop detection according to an embodiment of the present invention. It is understood that processing modules **202**, **204**, **206**, and **208** may each include one or more microprocessors for executing the various telecommunications applications that will be described herein and associated memory.

Link interface module **202** includes an SS7 level 1 and 2 function **212** for

15 performing error detection, error correction, and SS7 message sequencing. Gateway screening module **214** screens messages based on MTP information to determine whether to allow the messages into the network where STP **200** is located. Discrimination module **216** determines whether a received message should be routed or sent to an internal processing module for further

20 processing. Distribution module **218** receives messages identified by discrimination module **216** as requiring further processing. Routing module **220** receives messages identified by discrimination module **216** as requiring routing

and routes the message to the processor card associated with the appropriate outbound linkset.

Data communications module **204** may include a physical layer **222** for performing OSI physical layer functions and a data link layer **224** for performing
5 OSI data link layer functions. Layers **222** and **224** may be implemented using an appropriately configured Ethernet card.

DCM **204** also includes a network layer **226** and a transport layer **228**. Network layer **226** may implement Internet protocol (IP) communications. Transport layer **228** may implement OSI transport layer functions. Two
10 examples of protocols suitable for use as transport layer **228** include the transmission control protocol (TCP) and the stream control transmission protocol (SCTP).

In order to send and receive SS7 messages over an underlying IP network, DCM **204** may include an SS7 adapter layer **230**. SS7 adapter layer
15 **230** preferably adapts SS7 message traffic for transport over an underlying non-SS7 network. Examples of protocols suitable for use as SS7 adapter layer **230** include TALI, M3UA, SUA, and M2PA, as described in the correspondingly named IETF Internet Drafts and RFCs. DCM **204** may also include gateway screening module **214**, discrimination module **216**, distribution module **218**, and
20 routing module **220**. Modules **214-220** perform the same functions as those described above with regard to LIM **202**.

DSMs **206** and **208** each include a signaling connection routing controller (SCRC) **232** for overall control of SCCP functionality. For example,

SCRC **232** may call appropriate functions for performing global title translation and SCCP loop detection. In order to perform global title translation and SCCP loop detection, each DSM **206** may include a global title translation module **234** and an SCCP loop detector **236**. Global title translation module **234** preferably
5 performs global title translation on received signaling messages. SCCP loop detector **236** preferably determines whether SCCP looping is present based on correlation data stored in global title translation and point code correlation tables **238**. Exemplary data that may be stored in tables **238** will be described in detail below.

10 As discussed above, in some instances, network service providers may use capability point codes for load sharing purposes. Figure 3 is a flow chart illustrating exemplary steps that may be performed by an STP in performing SCCP loop detection in a network in which capability point codes are used. Referring to Figure 3, in step **300**, STP **200** receives an SS7 message and
15 routes the message to an SCCP card. Using the example illustrated in Figure 3, an SCCP message may arrive at LIM **202**. The message may pass SS7 level 1 and 2 and gateway screening. Discrimination function **216** determines that the message should be distributed to an internal subsystem because the message requires global title translation. Accordingly, discrimination function
20 **216** passes the message to distribution function **218**. Distribution function **218** distributes the message to DSM **206** for global title translation and SCCP loop detection processing.

In response to receiving the message, in step **302**, DSM **206** performs global title translation of the message. However, DSM **206** preferably does not replace the OPC in the routing label of the message prior to performing the SCCP looping logic. In step **304**, SCCP loop detector **236** determines whether

5 the inbound message is from an adjacent STP and whether the outbound message is addressed to an adjacent STP. If the inbound message is from an adjacent STP and the outbound message is to adjacent STP, control proceeds to step **306** where SCCP loop detector **236** determines whether the inbound OPC matches the outbound DPC using TPC/SPC-CPC correlations of the

10 originating STP that may be stored in GTT and point code correlation tables **238**. More particularly, step **306** may first include comparing the OPC of the inbound message with the post-GTT DPC and match any of the point codes associated with the message originator. If there is a match, an SCCP loop is detected, as indicated by step **308**. If there is not a match, the post-GTT DPC

15 may be compared to any point codes that correlate with the OPC in the outbound message. If the inbound post-GTT DPC matches any of the correlated point codes, an SCCP loop is detected. Once an SCCP loop is detected, in step **310**, the message is discarded. In step **312**, a UIM message is sent to the originator and a count is made of the SCCP loop.

20 Returning to step **304**, if the inbound message is not from an adjacent STP and/or the outbound message is not directed to an adjacent STP, control proceeds to step **314** where it is determined whether the outbound message is in the concurring or opposing direction. The concurring direction, as used

herein, refers to the same direction that the message was traveling when it was received, as defined in a predetermined network topology map, such as that illustrated in Figure 4 described below. An opposing direction, as used herein, refers to a direction opposite the direction from which a message was received.

- 5 The opposing and concurring directions will be described in more detail below with reference to specific call flows.

If it is determined that the received message is in the concurring direction, control proceeds to step **306**, where it is determined whether the post-GTT DPC matches any of the point codes associated with the message
10 originator. Steps **308**, **310**, **312**, and **314** are the same as those described above. In step **318**, if it is determined that the outbound message is in the opposing direction, control proceeds to step **320** where it is determined whether the inbound OPC matches the outbound DPC using the true point code of the originating STP and all other capability point codes for which looping detection
15 is desired. If the post-GTT DPC matches any of these point codes, control proceeds to steps **308-312** where an SCCP loop is detected, the message is discarded, and a UIM and a peg count are generated. In step **320**, if the post-GTT DPC does not match any of the point codes to which the inbound OPC correlates, control proceeds to step **314** where GTT is completed. Then,
20 control proceeds to step **316** where the message is routed to the destination specified by the DPC. Thus, using the steps illustrated in Figure 3, even in a network in which nodes use capability point codes, SCCP looping can be detected.

The present invention is not limited to correlating the inbound OPC to additional point codes and comparing the post-GTT DPC to the correlated point codes in order to detect the presence of SCCP looping. In an alternate embodiment of the invention, the post-GTT DPC may be mapped to a true point code and compared to the point code of the originating node. Either method for detecting SCCP looping is intended to be within the scope of the invention.

Figure 4 illustrates an example of a network in which routing nodes, such as STPs, utilize true point codes and capability point codes to identify each other. In the illustrated example, each STP includes a true point code, a secondary true point code, and a capability point code. The network diagram illustrated in Figure 4 includes network elements **100-110** described above with respect to Figure 1. In addition, the network diagram illustrated in Figure 4 includes STPs **400, 402, 404, and 406**, and an SCP **408**.

As described above with regard to Figure 3, SCCP loop detection depends on the direction of the incoming message and whether the message is sent from an adjacent node or a non-adjacent node. In networks in which nodes use capability point codes and STP according to an embodiment of the present invention may utilize the following rules:

1. For messages in the concurring direction, the receiving STP may check the incoming message OPC with the outbound post-GTT DPC using a check with the inbound STP's TPC and CPC only.

2. For messages in the opposing direction, the receiving STP may check the incoming message OPC with the outbound message GTT DPC by comparing the outbound message DPC to the inbound STP's PC and all other STPs' CPCs that correlate with the OPC.
3. For messages received from non-adjacent STPs, the post-GTT DPC is preferably compared to the TPC, SPC, and CPC of the sending node and all other STP CPCs that correlate with the OPC.
4. The mate STP's point codes are preferably not considered.

As stated above, the concurring direction refers to the same direction in which a message was previously traveling. A more formal definition is as follows:

- Concurring direction - A direction when the message flow from an STP ID view as shown in Figure 4 is either decrementing or incrementing, but not both.

For example, using the network diagram in Figure 4, a message flowing from an STP B 102 to STP D 106 to STP H 402 would be considered the concurring directions with regard to STP D 106, because the message travels in a direction of increasing-only STP pair IDs (1→2→3). In another example, a message from STP B 102 to STP H 402 to STP J 406 would be considered as flowing in the concurring direction by STP H 402 because the message flows

from STP pair 1 to 4 to 5. In yet another example, a message from STP H **402** to STP D **106** to STP B **102** would be considered as flowing in the concurring direction by STP D **106** because the message flows in a direction of decreasing-only STP pair IDs (4→2→1). In yet another example, a message
5 from STP J **406** to STP H **402** to STP E **110** would be considered as flowing in the concurring direction by STP H **402** because the message flows only in the direction of decreasing STP IDs (5→4→3).

As stated above, the opposing direction refers to the opposite direction from which a message is received. A more formal definition of “opposing
10 direction” may be “traveling in a direction of both incrementing and decrementing STP IDs.” Using the network diagram illustrated in Figure 4, a message from STP E **110** to STP H **402** to STP D **106** would be considered as flowing in the opposing direction by STP D **106** because the message flows from STP pair 3 to pair 4 to pair 2. In another example, a message from STP D
15 **106** to STP H **402** to STP D **102** would be considered as flowing in the opposing direction because the message flows from pair 2 to 4 to 2. In yet another example, a message from STP J **406** to STP E **110** and to STP H **402** would be considered as flowing in the opposing direction because the message flows from pair 5 to 3 to 4.

20 Table 1 shown below illustrates exemplary SCCP logic that may be implemented by an STP loop detector according to an embodiment of the present invention to prevent SCCP looping while allowing valid messages to be

translated in routing. This logic in Table 1 shown below is implemented in the flow chart illustrated in Figure 3.

Message Direction	Inbound Message	Outbound Message	Incoming OPC-Outbound DPC correlation
Concurring	Adjacent STP	Adjacent STP	Correlates CPC to PC of originating STP
Opposing	Adjacent STP	Adjacent STP	Correlates CPC to PC of originating STP
Concurring	Adjacent STP	Non-adjacent STP	Correlates CPC to PC of originating STP
Opposing	Adjacent STP	Non-adjacent STP	Correlates all other CPCs to PC of originating STP
Concurring	Non-adjacent STP	Adjacent STP	Correlates CPC to PC of originating STP
Opposing	Non-adjacent STP	Adjacent STP	Correlates all other CPCs to PC of originating STP
Concurring	Non-adjacent STP	Non-adjacent STP	Correlates CPC to PC of originating STP
Opposing	Non-adjacent STP	Non-adjacent STP	Correlates all other CPCs to PC of originating STP

Table 1: Logic Table for SCCP Looping for Networks that Use CPCs

5

Tables 2-6 shown below illustrate exemplary SPC/TPC=CPC mappings that may be used by STPs 100-110 and 400-406 illustrated in Figure 3 in performing SCCP loop detection according to an embodiment of the present invention. Each Table correlates TPCs and SCPs with CPCs for use in
 10 detecting looping when the post-GTT DPC and OPC of a message do not match. The use of the tables in detecting SCCP looping will be described with reference to specific message flows below.

STP GROUP	STP ID	TPC/SPC	CPC	Other CPCs
STP PAIR 2	STP D	6-6-6 6-6-7	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 2	STP C	4-4-4 4-4-5	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 3	STP F	8-8-8 8-8-9	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 3	STP E	7-7-7 7-7-8	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 4	STP G	7-7-0 7-7-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7
STP PAIR 4	STP H	8-8-0 8-8-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7
STP PAIR 5	STP I	9-9-1 9-9-2	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0
STP PAIR 5	STP J	9-9-3 9-9-4	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0

Table 2: TPC/SPC→CPC Mappings for STP B

STP GROUP	STP ID	TPC/SPC	CPC	Other CPCs
STP PAIR 1	STP A	1-1-1 1-1-2	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 1	STP B	3-3-3 3-3-4	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 3	STP F	8-8-8 8-8-9	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 3	STP E	7-7-7 7-7-8	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 4	STP G	7-7-0 7-7-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7
STP PAIR 4	STP H	8-8-0 8-8-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7
STP PAIR 5	STP I	9-9-1 9-9-2	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0
STP PAIR 5	STP J	9-9-3 9-9-4	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0

Table 3: TPC/SPC→CPC Mappings for STP D

STP GROUP	STP ID	TPC/SPC	CPC	Other CPCs
STP PAIR 1	STP A	1-1-1 1-1-2	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 1	STP B	3-3-3 3-3-4	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 2	STP D	6-6-6 6-6-7	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 2	STP C	4-4-4 4-4-5	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 4	STP G	7-7-0 7-7-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7
STP PAIR 4	STP H	8-8-0 8-8-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7
STP PAIR 5	STP I	9-9-1 9-9-2	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0
STP PAIR 5	STP J	9-9-3 9-9-4	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0

Table 4: TPC/SPC→CPC Mappings for STP E

STP GROUP	STP ID	TPC/SPC	CPC	Other CPCs
STP PAIR 1	STP A	1-1-1 1-1-2	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 1	STP B	3-3-3 3-3-4	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 2	STP D	6-6-6 6-6-7	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 2	STP C	4-4-4 4-4-5	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 3	STP F	8-8-8 8-8-9	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 3	STP E	7-7-7 7-7-8	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 5	STP I	9-9-1 9-9-2	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0
STP PAIR 5	STP J	9-9-3 9-9-4	9-9-7	2-2-2 5-5-5 9-9-9 9-9-0

Table 5: TPC/SPC→CPC Mappings for STP H

STP GROUP	STP ID	TPC/SPC	CPC	Other CPCs
STP PAIR 1	STP A	1-1-1 1-1-2	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 1	STP B	3-3-3 3-3-4	2-2-2	5-5-5 9-9-9 9-9-0 9-9-7
STP PAIR 2	STP D	6-6-6 6-6-7	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 2	STP C	4-4-4 4-4-5	5-5-5	2-2-2 9-9-9 9-9-0 9-9-7
STP PAIR 3	STP F	8-8-8 8-8-9	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 3	STP E	7-7-7 7-7-8	9-9-9	2-2-2 5-5-5 9-9-0 9-9-7
STP PAIR 4	STP G	7-7-0 7-7-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7
STP PAIR 4	STP H	8-8-0 8-8-1	9-9-0	2-2-2 5-5-5 9-9-9 9-9-7

Table 6: TPC/SPC→CPC Mappings for STP J

STP Database Provisioning

- 5 In order to implement the scheme illustrated in Table 1 and Figure 3 described above, an STP performing the loop detection function is preferably provisioned with information regarding other STPs. For example, the

information may include whether an STP is adjacent or non-adjacent and also include a pair identifier that identifies the pair number of the STP in the network for determining whether a message is traveling in the concurring or opposing direction. For example, for STP H **402** illustrated in Figure 4, the STP pairs
5 may be numbered 1-5 in the network, with 4 being identified by STP H **402** as its own pair identifier. For each STP pair number, data that may be stored includes the STP ID of each STP in the pair (e.g. STP A and STP B for pair #1), and the point codes associated with each STP ID. Once the pair IDs and STP data are entered, SCCP loop detectors **236** associated with each STP
10 may determine which STPs are adjacent using the STP pair IDs. For example, STP H **402** would determine that STP E **110**, STP F **108**, STP I **404**, and STP J **406** are adjacent using the pair IDs.

In order to illustrate the logic illustrated in Figure 3 and Table 1, several examples of SCCP loop detection will now be explained in detail. Figure 5 is a
15 message flow diagram illustrating an exemplary message flow for an inbound message received from an adjacent STP and resulting in an outbound message to an adjacent STP in the concurring direction. In the example illustrated in Figure 5, STP D **106** is assumed to be the receiving STP. A message MSU 1 is assumed to originate from SSP **112**. The message is sent
20 to STP B **102** as route on global title. STP B **102** receives the message, performs an intermediate global title translation on the message, and produces MSU 1A. MSU 1A is assumed to have the following fields:

MTP OPC = 3-3-3

MTP DPC = 5-5-5

CGPA OPC = 244-2-1

CDPA DPC = 5-5-5.

- 5 When STP D **106** receives the message, STP D performs a global title translation to produce a message with the following fields:

MTP OPC = 6-6-6

MTP DPC = 9-9-9

CGPA OPC = 1-1-1

10 CDPA DPC = 9-9-9.

- STP D **106** then performs SCCP loop detection for the message. In performing loop detection, STP D **106** compares the OPC in MSU 1A (3-3-3) and post-GTT DPC in MSU 1B (9-9-9) and determines that the point codes do not match. In the next level of SCCP loop detection, the SCCP loop detector in
- 15 STP D **106** determines that message 1A is from an adjacent STP, message 1B is flowing in a concurring direction, and the destination STP, STP E **110** is an adjacent STP. Accordingly, from Tables 1 and 3, STP D **106** correlates the true point code of the originating STP (3-3-3) and its capability point code (2-2-2). Since 2-2-2 does not match the post-GTT DPC (9-9-9), the message
- 20 passes loop detection.

Figure 6 is a network diagram illustrating an exemplary message flow for a message from adjacent STP to an adjacent STP in the opposing direction. In Figure 6, MSU 1 originates from SSP **112**. MSU 1 has the same fields as

described above for the example in Figure 5. STP B **102** global title translates MSU 1 to form MSU 1A. The OPC in MSU 1A is 3-3-3. The remaining fields are the same as those described above with respect to Figure 5. Upon receiving MSU 1A, STP D **106** performs global title translation to produce MSU

5 1B with a post-GTT DPC of 2-2-2. STP D **106** determines that the message is from an adjacent node, directed to an adjacent node, and the message flow is in the opposing direction. Accordingly, from Tables 1 and 3, STP D **106** correlates the CPC in the incoming message to the point code of the originating STP. In this case, the OPC in MSU 1A is 3-3-3. The OPC correlates to a CPC

10 of 2-2-2, and 2-2-2 matches the post-GTT DPC. As a result, MSU 1B fails the looping check. MSU 1B is preferably discarded by STP D **106**, rather than being routed to STP B **102**.

Figure 7 illustrates yet another example of SCCP loop detection according to an embodiment of the present invention. In Figure 7, a message

15 flow is illustrated where an inbound message is from an adjacent STP and the outbound message is to a non-adjacent STP in the concurring direction. Referring to Figure 7, MSU 1 originates from SSP **112** and is global title translated by STP B **106** into MSU 1A. MSU 1A arrives at STP D **106**. STP D

20 **106** performs global title translation on the message to result in a post-GTT DPC of 9-9-0, which is a capability point code of STP H **302**. Accordingly, STP D **106** determines that the message is from an adjacent STP and destined for a non-adjacent STP and the concurring direction. From Table 1, in this situation, STP D **106** maps the OPC to the CPC of the originating node. From Table 3,

the OPC in the incoming message correlates to a CPC of 2-2-2. The post-GTT DPC, however, is 9-9-0, which does not match 2-2-2. Accordingly, MSU 1B passes the looping check and is routed to STP H **402**.

Figure 8 is a message flow diagram illustrating loop detection for the
5 inbound messages from an adjacent STP and the outbound messages to a
non-adjacent STP in the opposing direction. Referring to Figure 8, SSP **112**
originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** global title
translates MSU 1 into MSU 1A and forwards MSU 1A to STP D **106**. STP D
106 performs global title translation on MSU 1A to produce MSU 1B. The OPC
10 in MSU 1B is 6-6-6, and the DPC is 9-9-9, which corresponds to STP E.
Accordingly, STP D **106** routes MSU 1B to STP E **110**. STP E **110** receives
MSU 1B and global title translates MSU 1B to produce MSU 1C. MSU 1C is
assumed to have the following fields after global title translation:

MTP OPC = 8-8-8
15 MTP DPC = 2-2-2
CGPA OPC = 1-1-1
CDPA DPC = 2-2-2.

STP E **110** determines that the message is from an adjacent STP (STP D **106**)
and destined for a non-adjacent STP (STP B **102**) in the opposing direction.
20 Accordingly, from Table 1, STP E **110** preferably correlates all other CPCs to
the PC of the originating STP. The OPC in the message received by STP E
110 is 6-6-6. From Table 4, 6-6-6 correlates to 5-5-5, 2-2-2, 9-9-9, 9-9-0 and 9-
9-7. Since 2-2-2 matches the post-GTT DPC, MSU 1C fails the looping check.

Figure 9 is a message flow diagram illustrating exemplary loop detection for a message received from a non-adjacent STP and destined for a non-adjacent STP in the concurring direction. In Figure 9, SSP **112** originates MSU 1 and routes the message to STP B **102**. STP B **102** global title translates the message to produce MSU 1A and routes MSU 1A to STP D **106**. STP D **106** global title translates MSU 1A to produce MSU 1B. MSU 1B has a destination point code of 9-9-0, which corresponds to STP H. Accordingly, STP D **106** routes the message to STP H **402**. Upon receiving the message, STP H **402** performs global title translation to produce MSU 1C. MSU 1C is assumed to have the following fields:

MTP OPC = 8-8-0

MTP DPC = 9-9-7

CGPA OPC = 1-1-1

CDPA DPC = 9-9-7.

STP H **402** determines that the message is from a non-adjacent STP, destined to an adjacent STP in the concurring direction. Accordingly, from Table 1, STP H **402** correlates the CPC to the PC of originating STP. In this example, the point code of the originating STP is 6-6-6. Using Table 5 above, 6-6-6 correlates to a CPC of 5-5-5. Since 5-5-5 does not match the MTP DPC in the message, the message passes the SCCP looping check. It should be noted that 9-9-7 is in the other CPC column for TPC/STP equals 6-6-6. However, this column is not checked in this case. Thus, by selectively correlating the OPC to

predetermined sets of CPCs, an SCCP loop detector according to the present invention prevents SCCP looping while allowing valid messages to pass.

Figure 10 is a message flow diagram illustrating exemplary SCCP loop detection for a message originating from a non-adjacent STP to a non-adjacent
5 STP in the opposing direction. Referring to Figure 10, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** global title translates MSU 1 to produce MSU 1A. The post-GTT DPC and MSU 1A corresponds to STP D **106**. Accordingly, STP B **102** routes MSU 1A to STP D **106**.

STP D **106** receives MSU 1A and global title translates MSU 1a to
10 produce MSU 1B. MSU 1B is assumed to have a post-GTT DPC of 9-9-0. Accordingly, 9-9-0 corresponds to STP H **402**. Accordingly, STP D **106** routes MSU 1B to STP H **402**.

STP H **402** global title translates MSU 1b to produce MSU 1C. In this example, MSU 1C is assumed to have the following fields:

15 MTP OPC = 8-8-0
MTP DPC = 9-9-9
CGPA OPC = 1-1-1
CDPA DPC = 9-9-9.

STP H **402** determines that the message is from a non-adjacent STP and
20 destined for an adjacent STP in the opposing direction. Accordingly, using Table 1, STP H **402** correlates the OPC of the originating node (STP D) and all other CPCs. The OPC of the originating node is 6-6-6. Using Table 5, 6-6-6 correlates to 5-5-5, 2-2-2, 9-9-9, 9-9-0, and 9-9-7. Since 9-9-9 matches the

MTP DPC, MSU 1C fails the looping check. Accordingly, STP H **402** preferably discards MSU 1C.

Figure 11 illustrates SCCP screening for an inbound message from a non-adjacent STP and an outbound message to a non-adjacent STP in the concurring direction. Referring to Figure 11, SSP **112** originates MSU 1 and sends MSU 1 to STP B **102**. STP B **102** performs global title translation for MSU 1 to produce MSU 1A. The destination point code for MSU 1A is assumed to be that of STP E **110**. Accordingly, STP B **102** forwards MSU 1A to STP E **110**. STP E **110** receives MSU 1A, performs global title translation to produce MSU 1B, determines if the message is from a non-adjacent STP and is directed to a non-adjacent STP in the concurring direction. Accordingly, from Table 1, STP E **110** correlates the true point code with the capability point codes of STP B. From Table 3, the true point code of STP B correlates to 2-2-2. Since 2-2-2 does not match the post-GTT DPC (9-9-7), MSU 1B passes SCCP loop detection. Accordingly, STP E **110** routes MSU 1B to its intended destination.

Figure 12 illustrates exemplary SCCP loop detection for an inbound message from a non-adjacent STP and an outbound message to a non-adjacent STP in the opposing direction. Referring to Figure 12, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** global title translates MSU 1 to produce MSU 1A. MSU 1A has a destination point code of 8-8-0. Accordingly, STP B **102** forwards MSU 1A to STP H **402**. STP H **402**

performs global title translation for MSU 1A to produce MSU 1B. MSU 1B is assumed to have the following fields:

MTP OPC = 8-8-0

MTP DPC = 5-5-0

5 CGPA OPC = 1-1-1

CDPA DPC = 5-5-5.

STP H **402** determines that MSU 1A is from a non-adjacent STP and MSU 1B is directed to a non-adjacent in the concurring direction. Accordingly, from Table 1, STP H correlates the true point code of STP B to all other STPs in its point code correlation table illustrated in Table 5. In Table 5, the true point
10 code 3-3-3 of STP B **102** correlates to 2-2-2, 5-5-5, 9-9-9, 9-9-0, and 9-9-7. Since 5-5-5 matches the post-GTT DPC in MSU 1B, MSU 1B fails the looping check. Accordingly, STP H **402** preferably discards MSU 1B.

15 Networks Not Using Capability Point Codes

In some networks, network service providers may not use capability point codes to identify signal transfer points. An SCCP loop detector according to the present invention may be structured to prevent SCCP looping in such a network. Figure 13 illustrates an exemplary network in which STPs do not use
20 capability point codes. In Figure 13, each network element is the same as the correspondingly numbered network elements in Figure 4. However, in the illustrated example, each STP includes a true point code and a secondary point code but no capability point code. Table 7 shown below illustrates exemplary

logic that may be used by the STPs illustrated in Figure 13 in detecting and preventing SCCP looping. Similarly, Tables 8-12 are point code correlation tables that may be used by the correspondingly named STPs in Figure 13 in detecting and preventing SCCP looping. The use of Tables 7-12 to detect

5 SCCP looping will be illustrated below using specific message flow examples.

Message Direction	Inbound Message	Outbound Message	Incoming OPC- Outbound DPC correlation
Concurring	Adjacent STP	Adjacent STP	Correlates PC to PC of originating STP
Opposing	Adjacent STP	Adjacent STP	Correlates PC to PC of originating STP
Concurring	Adjacent STP	Non-adjacent STP	Correlates PC to PC of originating STP
Opposing	Adjacent STP	Non-adjacent STP	Correlates all other PCs to PC of originating STP
Concurring	Non-adjacent STP	Adjacent STP	Correlates PC to PC of originating STP
Opposing	Non-adjacent STP	Adjacent STP	Correlates all other PCs to PC of originating STP
Concurring	Non-adjacent STP	Non-adjacent STP	Correlates PC to PC of originating STP
Opposing	Non-adjacent STP	Non-adjacent STP	Correlates all other PCs to PC of originating STP

Table 7: SCCP Loop Detection Logic for STPs in Networks Where STPs Do Not Use CPCs

10 In Table 7, each row represents a rule that may be implemented by an SCCP loop detector in a network that does not use capability point codes. As with the capability point code example, the rules include correlating point codes of originating STPs and other STPs.

STP GROUP	STP ID	Self TPC	CPC	Other TPCs
STP PAIR 2	STP D	6-6-6	-	1-1-1 3-3-3 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 2	STP C	4-4-4	-	1-1-1 3-3-3 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 3	STP F	8-8-8	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 3	STP E	7-7-7	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 4	STP G	7-7-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3

STP PAIR 4	STP H	8-8-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3
STP PAIR 5	STP I	9-9-1	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0
STP PAIR 5	STP J	9-9-3	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0

Table 8: TPC-TPC Mappings for STP B

STP GROUP	STP ID	Self TPC	CPC	Other TPCs
STP PAIR 1	STP A	1-1-1	-	4-4-4 6-6-6 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 1	STP B	3-3-3	-	4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 3	STP F	8-8-8	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 3	STP E	7-7-7	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 4	STP G	7-7-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3

STP PAIR 4	STP H	8-8-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3
STP PAIR 5	STP I	9-9-1	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0
STP PAIR 5	STP J	9-9-3	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0

Table 9: TPC-TPC Mappings for STP D

STP GROUP	STP ID	Self TPC	CPC	Other TPCs
STP PAIR 1	STP A	1-1-1	-	4-4-4 6-6-6 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 1	STP B	3-3-3	-	4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 2	STP D	6-6-6	-	1-1-1 3-3-3 7-7-7 8-8-8 8-8-0 9-9-1 9-9-3
STP PAIR 2	STP C	4-4-4	-	1-1-1 3-3-3 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 4	STP G	7-7-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3

STP PAIR 4	STP H	8-8-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3
STP PAIR 5	STP I	9-9-1	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0
STP PAIR 5	STP J	9-9-3	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0

Table 10: TPC-TPC Mappings for STP E

STP GROUP	STP ID	TPC	CPC	Other TPCs
STP PAIR 1	STP A	1-1-1	-	4-4-4 6-6-6 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 1	STP B	3-3-3	-	4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 2	STP D	6-6-6	-	1-1-1 3-3-3 7-7-7 8-8-8 8-8-0 9-9-1 9-9-3
STP PAIR 2	STP C	4-4-4	-	1-1-1 3-3-3 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 3	STP F	8-8-8	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3

STP PAIR 3	STP E	7-7-7	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 5	STP I	9-9-1	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0
STP PAIR 5	STP J	9-9-3	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0

Table 11: TPC-TPC Mappings for STP H

STP GROUP	STP ID	Self TPC	CPC	Other TPCs
STP PAIR 1	STP A	1-1-1	-	4-4-4 6-6-6 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 1	STP B	3-3-3	-	4-4-4 6-6-6 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 2	STP D	6-6-6	-	1-1-1 3-3-3 7-7-7 8-8-8 8-8-0 9-9-1 9-9-3
STP PAIR 2	STP C	4-4-4	-	1-1-1 3-3-3 7-7-7 8-8-8 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 3	STP F	8-8-8	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3

STP PAIR 3	STP E	7-7-7	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-0 8-8-0 9-9-1 9-9-3
STP PAIR 4	STP G	7-7-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3
STP PAIR 4	STP H	8-8-0	-	1-1-1 3-3-3 4-4-4 6-6-6 7-7-7 8-8-8 9-9-1 9-9-3

Table 12: TPC-SPC Mappings for STP J

As with the examples discussed above, each STP may be provisioned with pair IDs for the other STPs and point codes for the individual STPs in the pair. This allows each STP to determine whether an STP is adjacent or nonadjacent and whether a message flow is in the concurring or the opposing direction.

Figure 14 is a flow chart illustrating exemplary steps that may be performed by an STP in detecting and preventing SCCP looping in a network in which nodes do not use capability point codes. Referring to Figure 14, in step 1400, an STP receives an MSU and routes the MSU to an SCCP card. In step

1402, the STP performs a global title translation lookup and translates the MTP DPC in the message but does not replace the OPC. In step **1404**, the STP determines whether the inbound message is from an adjacent STP and whether the outbound message is to an adjacent STP. If the answer to both of
5 these inquiries is yes, control proceeds to step **1406** where the STP determines whether the inbound OPC matches the outbound DPC of the originating STP. If the post-GTT DPC matches the inbound OPC, an SCCP loop is detected, as indicated by step **1408**. Accordingly, control proceeds to step **1410** where the message is discarded. In step **1412**, the STP generates a UIM and
10 measurement peg. Returning to step **1406**, if the inbound OPC does not match the post-GTT DPC, the message passes SCCP looping, and control proceeds to step **1414** where the global title translation is completed. In step **1416**, the message is routed to its intended destination.

Returning to step **1404**, if the inbound message is not from an adjacent
15 STP and/or the outbound message is not to an adjacent STP, control proceeds to step **1418** where the STP determines whether the message is in a concurring or opposing direction. If the message is in a concurring direction, control proceeds to steps **1406-1416** where loop detection is performed based on the post-GTT DPC and the originating OPC. If the message is in the
20 opposing direction, control proceeds to step **1420** where the STP determines whether the inbound OPC matches the outbound DPC using the TPC of the originating STP and all other STPs for which loop detection is desired. If the inbound OPC matches any of these DPCs, control proceeds to steps **1408-**

1412 where an SCCP loop is detected and the message is discarded. If the message does not match any of the DPCs, control proceeds to steps **1414** and **1416** where the message is routed to its intended destination.

Figure 15 illustrates an exemplary message flow for an inbound message from an adjacent STP and an outbound message to an adjacent STP in the concurring direction. Referring to Figure 15, SSP **112** originates MSU 1 and addresses MSU 1 to STP B **102**. STP B **102** performs global title translation on MSU 1 to produce MSU 1A. The OPC in MSU 1a is 3-3-3. The DPC in MSU 1A is that of STP D **106**.

STP D **106** receives MSU 1A and performs global title translation to produce MSU 1B. MSU 1B is assumed to have the following fields:

MTP OPC = 6-6-6

MTP DPC = 8-8-8

CGPA OPC = 1-1-1

CDPA DPC = 8-8-8.

STP D **106** determines that the incoming messages from the adjacent STP and the outgoing messages are to an adjacent STP in the concurring direction. Accordingly, from Table 7, STP D **106** checks whether the post-GTT DPC (8-8-8) matches the point code of the originating node (3-3-3). Since there is no match, the message passes SCCP looping and STP D **106** routes the message to its intended destination.

Figure 16 is a message flow illustrating exemplary SCCP loop detection for an inbound message from an adjacent STP and an outbound message to

an adjacent STP in the opposing direction. Referring to Figure 16, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** global title translates MSU 1 to produce MSU 1A. MSU 1A includes an OPC of 3-3-3 and a DPC of 6-6-6. Accordingly, STP B **102** routes MSU 1A to STP D **106**.

5 STP D **106** receives MSU 1A and global title translates MSU 1A to produce MSU 1B. MSU 1B is assumed to have the following fields:

MTP OPC = 6-6-6

MTP DPC = 3-3-3

CGPA OPC = 1-1-1

10 CDPA DPC = 6-6-6.

STP D **106** determines that the incoming messages from an adjacent node and the outgoing messages to an adjacent node in the opposing direction. Accordingly, from Table 1, STP D **106** compares the post-GTT DPC to the OPC in the received message. Since the post-GTT DPC (3-3-3) matches the
15 originating message OPC, SCCP looping is detected. Accordingly, STP D **106** preferably discards MSU 1B.

Figure 17 is a message flow diagram illustrating exemplary SCCP loop detection for an inbound message from an adjacent STP and an outbound message to a non-adjacent STP in the concurring direction. Referring to Figure
20 17, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** global title translates MSU 1 to produce MSU 1A. MSU 1A is addressed to STP D **106**. Accordingly, STP B **102** forwards MSU 1A to STP D **106**.

STP D **106** global title translates MSU 1A to produce MSU 1B. MSU 1B is assumed to have the following fields:

MTP OPC = 6-6-6

MTP DPC = 8-8-0

5 CGPA OPC = 1-1-1

CDPA DPC = 8-8-0.

STP D **106** determines that the incoming message is from an adjacent STP and that the outgoing message is to a non-adjacent STP in the concurring direction. Accordingly, from Table 1, STP D **106** preferably correlates the post-
10 GTT DPC to the OPC in the received message. In this case, because the post-GTT DPC (8-8-0) does not match the OPC in MSU 1A (3-3-3), the message passes SCCP loop detection.

Figure 18 is a message flow diagram illustrating SCCP loop detection for an inbound message from an adjacent STP and an outbound message to a
15 non-adjacent STP in the opposing direction. Referring to Figure 18, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** global title translates MSU 1 to produce MSU 1A. STP B **102** forwards MSU 1A to STP D **106**.

STP D **106** global title translates MSU 1A to produce MSU 1B. MSU 1B
20 is assumed to have a destination point code of 8-8-8. Accordingly, STP D **106** forwards MSU 1B to STP E **110**.

STP E **110** global title translates MSU 1b to produce MSU 1c. MSU 1c is assumed to have the following fields:

MTP OPC = 8-8-8

MTP DPC = 3-3-3

CGPA OPC = 1-1-1

CDPA DPC = 3-3-3.

- 5 STP E **110** determines that the incoming message is from an adjacent STP and that the outgoing message is to a non-adjacent STP in the opposing direction. Accordingly, from Table 7, STP E **110** correlates the true point code of STP D (6-6-6) to all other TPCs/SPCs shown in the point code correlation table (Table 10). From Table 10, one of the point codes that 6-6-6 correlates to
10 is 3-3-3. Since 3-3-3 matches the MTP DPC in the message, MSU 1C fails SCCP loop detection and STP E **110** preferably discards MSU 1C.

Figure 19 is a message flow diagram illustrating exemplary SCCP loop detection for an inbound message from a non-adjacent STP and an outbound message to an adjacent STP in the concurring direction. Referring to Figure
15 19, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** global title translates MSU 1 to produce MSU 1A. MSU 1A has a DPC of 6-6-6. Accordingly, STP B **102** forwards MSU 1A to STP D **106**.

STP D **106** global title translates MSU 1A to produce MSU 1B. MSU 1B has a destination point code of 8-8-8. Accordingly, STP D **106** routes MSU 1B
20 to STP H **402**.

STP H **402** receives MSU 1B and global title translates MSU 1B to produce MSU 1C. MSU 1C is assumed to have the following values after global title translation:

MTP OPC = 8-8-0

MTP DPC = 9-9-3

CGPA OPC = 1-1-1

CDPA DPC = 9-9-3.

5 STP H **402** determines that the incoming message is from a non-adjacent STP and that the outgoing message is to an adjacent STP in the concurring direction. Accordingly, from Table 7, STP H **402** preferably compares the incoming OPC to the post-GTT DPC. Since the incoming message OPC (6-6-6) does not match the post-GTT DPC (9-9-3), MSU 1C
10 passes SCCP loop detection and is routed to its intended destination.

Figure 20 is a message flow diagram illustrating exemplary SCCP loop detection for an inbound message from a non-adjacent STP and an outbound message to an adjacent STP in the opposing direction. Referring to Figure 20, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102**
15 global title translates MSU 1 to produce MSU 1A. MSU 1A has a post-GTT DPC of 6-6-6. Accordingly, STP B **102** forwards MSU 1A to STP D **106**.

STP D **106**, upon receiving MSU 1A, performs global title translation to produce MSU 1B. The post-GTT DPC of MSU 1B is assumed to be 8-8-0. Accordingly, STP D **106** forwards MSU 1b to STP H **302**.

20 STP H **402**, upon receiving MSU 1B, global title translates MSU 1B to produce MSU 1C. MSU 1C is assumed to have the following fields after global title translation:

MTP OPC = 6-6-6

MTP DPC = 8-8-0

CGPA OPC = 1-1-1

CDPA DPC = 8-8-0.

5 STP H **402** determines that the incoming message is from a non-adjacent STP and the outgoing message is to an adjacent STP in the opposing direction. Accordingly, STP H **402** correlates the OPC in the originating message to all other point codes in its point code correlation table. Referring to Table 11, 6-6-6 correlates to 4-4-4, 6-6-6, 7-7-7, 8-8-8, 7-7-0, 8-8-0, 9-9-1, and 9-9-3. Since
10 8-8-0 matches the post-GTT DPC, MSU 1C fails loop detection and is preferably discarded.

Figure 21 is a message flow diagram illustrating exemplary SCCP loop detection for an inbound message from a non-adjacent STP and an outbound message to a non-adjacent STP in the concurring direction. Referring to Figure
15 21, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102** performs global title translation to produce MSU 1A. The post-GTT DPC of MSU 1a is 8-8-8. Accordingly, STP B **102** forwards MSU 1a to STP E **110**.

STP E **110** receives MSU 1A and global title translates MSU 1A to produce MSU 1B. MSU 1B is assumed to have the following fields:

20 MTP OPC = 8-8-8
MTP DPC = 9-9-3
CGPA OPC = 1-1-1
CDPA DPC = 9-9-3.

STP E **110** determines that MSU 1A is from a non-adjacent STP and MSU 1B is to a non-adjacent STP in the concurring direction. Accordingly, from Table 7, STP E **110** compares the post-GTT DPC (9-9-3) to the incoming message OPC (3-3-3). Since there is no match, MSU 1B passes loop detection is routed to its
5 intended destination.

Figure 22 is a message flow diagram illustrating exemplary SCCP loop detection for an inbound message from a non-adjacent STP and an outbound message to a non-adjacent STP in the opposing direction. Referring to Figure 22, SSP **112** originates MSU 1 and forwards MSU 1 to STP B **102**. STP B **102**
10 global title translates MSU 1 to produce MSU 1A. MSU 1A is assumed to have a destination point code of 8-8-0. Accordingly, STP B **102** routes MSU 1A to STP H **302**.

STP H **402**, upon receiving MSU 1A, global title translates MSU 1A to produce MSU 1B. MSU 1B is assumed to have the following values after
15 global title translation:

MTP OPC = 8-8-0

MTP DPC = 6-6-6

CGPA OPC = 1-1-1

CDPA DPC = 6-6-6.

20 STP H **402** determines that the incoming message is from a non-adjacent STP and the outgoing message is to a non-adjacent STP in the opposing direction. Accordingly, from Table 7, STP H **402** correlates the OPC in the inbound message to all point codes in its point code correlation table. Referring to

Table 11, the incoming message OPC (3-3-3) correlates to 4-4-4, 6-6-6, 7-7-7, 8-8-8, 7-7-0, 8-8-0, 9-9-1, and 9-9-3. Since 6-6-6 matches the post-GTT DPC, MSU 1B fails loop detection and is preferably discarded.

Thus, using the logic and tables described above, the embodiments of
5 the present invention are capable of detecting SCCP looping, even when the incoming message OPC does not match the outgoing message DPC. In addition, because the loop detection functions performed by embodiments of the present invention depend on the message direction and whether or not an STP is adjacent or non-adjacent, loop detection can be performed without discarding
10 valid messages. Thus, the present invention provides increased versatility over conventional solutions and reduces the likelihood of both SCCP looping and discarding of valid messages.

It will be understood that various details of the invention may be changed without departing from the scope of the invention. Furthermore, the
15 foregoing description is for the purpose of illustration only, and not for the purpose of limitation, as the invention is defined by the claims as set forth hereinafter.